Exhibit 1

The Design Of Front-End DC-DC Converters Of Distributed Power Supply Systems With Improved Efficiency And Stability

by

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Chapter 1

Front-End Converters for Distributed Power Supply Systems

1.1 Objectives of the Thesis

Most electronic systems today use centralized power supplies. In these systems, the ac-mains to dc circuit level conversion is done at a central point, from which power is distributed at the circuit level voltages to the various circuit boards. This power supply architecture is shown in Fig. 1.1a. This method of powering electronic systems has serious drawbacks. Because circuit level voltages are typically low (±15 V, +5 V), and currents are high, the distribution bus is large in high power systems, and the supply as a whole is too big. If there is a failure in one part of a centralized supply system, this typically brings down the whole system.

In recent years, distributed power supply systems have received a lot of attention as alternatives to centralized supplies. A distributed power supply system is illustrated in Fig. 1.1b. It consists of a front-end converter which processes the mains voltage to produce a dc distribution bus voltage in the 50 V range. The bus voltage is distributed to point-of-load converters on the individual circuit boards which then transform it to the required +5 V or ±15 V level.

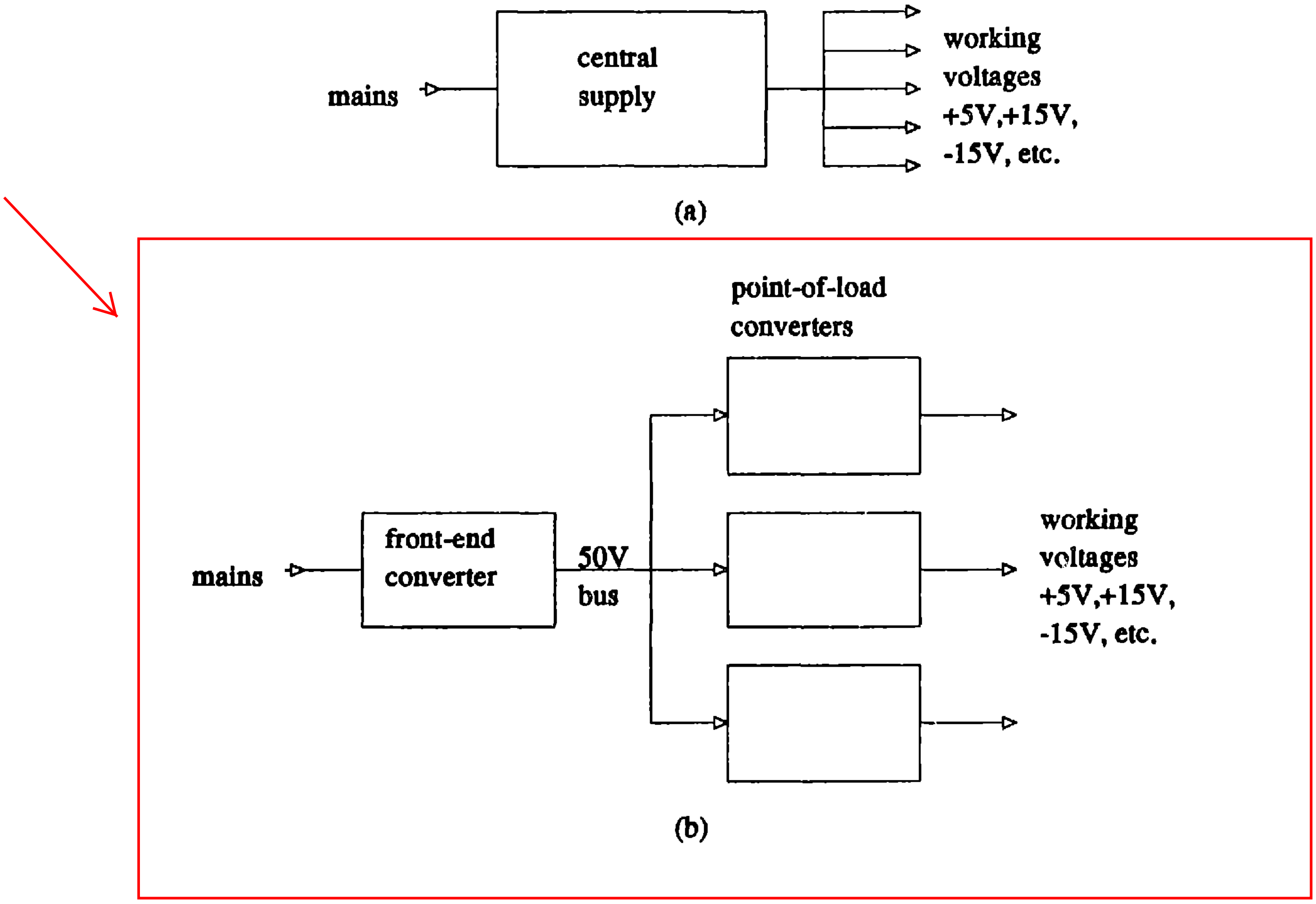

Figure 1.1: Centralized and distributed power supplies

The advantages of the distributed power supply over a bulk system have been frequently enumerated[1, 2, 5]. Among them are the following. The high distribution voltage compared to the working level voltages leads to reduced space, heat and dc bussing requirements in comparison to the centralized supply. This improves the cost, reliability, maintainability and flexibility of the distributed supply. Strategic redundancy can be built into vulnerable points, and idle modules can be powered down. The power supply can take advantage of existing off-the shelf modules, and the option of modular growth can be easily accommodated.

This thesis deals with the design of front-end converters that will perform their task as efficiently and compactly as possible. The main functions of a front-end converter are

1. to rectify the mains voltage
2. to convert the rectified voltage to the 50 V dc bus
3. and to isolate the bus from the mains.

The most straightforward front-end converter is simply a rectifier and an isolated buck converter stage, as shown in Fig. 1.2b. Front-end converters are standardly built this way using PWM operated bridges. The biggest advantage of this approach is its simplicity. One of its main shortcomings is the fact that the switching losses of traditionally operated bridges become too great as the switching frequency is increased. Another is that the step-down stage has to maintain a constant output voltage over a rather wide input voltage range, typically 3 to 1, and this, for a down converter, compromises the attainable efficiency.

This thesis is mainly concerned with making modifications to the operation and topologies of standard bridges to remove the power losses due to the energy stored in parasitic circuit elements. But even with the switching losses eliminated, the deleterious effects of the wide input voltage range, manifested in increased conduction losses, still remain. This thesis therefore proposes a two-stage front-end converter, illustrated in Fig. 1.2b, to alleviate this problem. The input voltage is first raised

Chapter 8

Stability of the Distribution Bus

8.1 Objectives

In developing an optimum front-end converter, this thesis has, to this point, treated the problem from the efficiency standpoint. To this end, modified and improved ways of operating the standard topologies have been investigated. The result has been the development of the highly efficient front-end converter presented in Chapters 5, 6 and 7. However, efficiency is just one of several important performance measures. Another vital consideration is the stability of the overall distributed power supply system. When the front-end converter and the point-of-load converters are integrated, filters have to be interposed between them to mitigate the deleterious effects of the harmonic currents generated by the switching action of the converters. Unfortunately, instability often attends the addition of these filters to the system.

This instability is due to the fact that the low-frequency input impedance of dc-dc converters is a negative resistance. This negative resistance can interact with the filters to cause oscillations. The purpose of this chapter is to investigate and compare the stability properties of the distribution bus when the front-end converter is either a regulated unit or the unity duty ratio, unregulated isolation stage described at length in Chapters 6 and 7.